

## PATENT SPECIFICATION

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## COMPLETE SPECIFICATION

## Improvements in or relating to Processes and Apparatus for the Manufacture of Beads

We, UNION DES VERRERIES MECANIQUES BELGES SOCIETE ANONYME, a Belgian Company, of 29, Quai de Brabant, Charleroi, Belgium, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a process and apparatus for the manufacture of small solid balls (beads) which are generally used in the construction of beaded reflecting systems (cinema screens, road traffic signalling plates and strips, advertising panels, etc.) and herein-after referred to as "beads".

These small balls, the diameter of which is generally a fraction of a millimetre, are manufactured by means of glass chips of various compositions which are previously finely crushed.

It is known to manufacture beads by injecting a pre-heated mixture of glass granules, a fluid which supports combustion and/or a combustible fluid into a flame which is fed by the two fluids, in which flame the said granules are converted by melting and by the action of surface tension, into beads which are then cooled and separated from the vehicle gases.

It is also known to manufacture beads by injecting the glass granules with the fluid supporting combustion and/or with the combustible fluid through a burner directed upwardly in the lower end of a substantially vertical tubular column, while imparting to the vehicle gases a velocity which is sufficient in order to entrain the glass granules, and the beads which are formed therefrom, towards the upper part of the tubular column, and at the same time to subject a section of the column to a cooling action which is designed to cool the beads. After which the beads are separated from the vehicle gases in a separator provided in the upper part of the column.

The known processes and apparatus generally do not produce a uniform bead, because the process of pre-heating, suspending and

melting the granules in the flame, and also the process of cooling the beads which are formed, are too imperfect, so that, on the one hand, a high proportion of the glass granules remain unmelted and are found in the finished product and in angular form or more or less ovoidal form and that, on the other hand, a high proportion of beads is obtained in a form in which the beads are joined together and cannot be used.

According to the present invention there is provided a process for manufacturing beads (solid glass spherules) by the thermal treatment of glass granules obtained by crushing glass chips, in which process a pre-heated mixture of the said granules, a fluid supporting combustion and/or a combustible fluid serving as vehicle media is injected into a flame fed by the fluids, and in which said granules are transformed by fusion and surface tension into beads which beads are then cooled and separated from the vehicle fluids, wherein the pre-heating of the glass granules is continued up to a temperature slightly or immediately below the softening temperature of the glass and is carried out at a high speed as a result of the granules being dispersed in at least one of the said fluids, which latter is previously pre-heated to a temperature a little higher than the said softening temperature.

The glass granules are advantageously pre-heated rapidly, first of all up to a temperature slightly or immediately below their softening temperature and then up to the softening temperature by their introduction into, and during their entrainment by, one or the two initially pre-heated fluids feeding a flame which is preferably directed upwardly, they are then injected in this pre-heated condition with the said fluid or fluids into the said flame and are brought by the latter rapidly to a temperature higher than their softening temperature, and the beads thus formed are subjected to a cooling process, advantageously in three stages, the first of which is sudden and terminates at the upper point of structural transformation, the second is moderate and terminates at the lower

- point of structural transformation and the third is sudden and terminates at a temperature slightly higher than  $100^{\circ}$ ; after this, the beads are separated from the vehicle gases and 5 are collected in a possibly graded condition by a centrifuging operation, according to their order of size. The flame is formed within an orientatable rising air current, the speed and temperature of which are adjustable.
- 10 The gas current charged with the shaped beads is caused to pass through a cooling zone of increasing intensity. The process is effectively carried out in an apparatus comprising a substantially vertical tubular column, the lower end of which has opening thereinto an upwardly directed burner which is supplied with fuel, a supporter of combustion and glass granules, while the upper end of the said column adjoins a 15 centrifugal separator, the said apparatus being characterised in that at least one of the parts of the burner fed with a supporter of combustion and/or with fuel is connected to the source of the fluids in question by means of a 20 pre-heating jacket surrounding at least one refrigeration zone of the column and to the said jacket by at least one pipe, into which opens the means for feeding glass granules.
- For a better understanding of the invention 25 and to show how the same may be carried into effect reference will now be made to the accompanying drawing, in which:—
- Figure 1 shows a diagram representing the course of the thermal treatment applied to the 30 glass granules and to the resultant beads as a function of changes of the physical state experienced by the granules and the beads during the treatment.
- Figures 2, 3 and 4 represent preferred 35 embodiments of the apparatus for carrying into effect the process according to the invention, viz:—
- Figure 2 is a diagrammatic elevation of the complete apparatus, partly in section; 40
- Figure 3 is a section of the line III—III of Figure 2;
- Figure 4 is a diagrammatic vertical section of one modification of the separator.
- It will be understood from what has been 45 stated above that, the glass granules are advantageously subjected to a thermal treatment consisting essentially of five characteristic stages, as indicated by the diagram according to Figure 1, these stages being:—
- 50 Phase a: rapid pre-heating phase in two consecutive steps, the first terminating at a temperature slightly lower than  $T_r$ , the latter being the softening temperature of the treated glass, while the second step terminates at the temperature  $T_r$ .
- Phase b: phase of moving in the flame: sudden heating up to a temperature  $T_b$  higher than  $T_r$ .
- Phase c: abrupt cooling down to a tem- 55 perature in the region of  $T_{\beta}$ , this being the

upper point of structural transformation, that is to say, the point above which the internal tensions cannot be set up.

Phase d: moderate cooling phase between the temperature  $T_{\beta}$  and  $T_a$ , the latter being 70 the lower point of structural transformation, that is to say, the points below which the internal stresses can no longer be established.

Phase e: sudden cooling phase down to the outlet temperature  $T_s$ , of the vertical column 75 forming part of the apparatus for carrying the present process into effect. At the end of this phase, the natural cooling is produced during evacuation, the temperature of the vehicle gases at the instant of their separation from 80 the beads preferably being slightly higher than  $100^{\circ}$  C., in order to avoid the condensation of the water vapour on the beads.

According to the invention the phase "a" 85 is carried out by introducing the glass granules, preferably into the previously heated combustion air.

The glass granules could be introduced also into the fuel gas. It is, however, simpler to preheat the air, because if fuel gas is passed 90 through the pre-heating ducts shown in the drawing, it is possible that cracking of the fuel gas, depending upon the composition of the fuel gas might occur. Consequently precaution would be required to prevent such 95 cracking.

This pre-heating is carried out by causing the air for combustion to circulate in cooling jackets which enclose the upper part of the apparatus.

It is obviously possible to obtain the same result with the combustible gas.

As it is necessary to bring the glass granules to a temperature in the region of  $T_r$ , it has been found that it is important to prevent them 105 from sticking to one another. The procedure adopted is as follows: the air is pre-heated to a temperature slightly higher than  $T_r$ . The granules are introduced into this air before it enters the burner. They are thus suddenly 110 heated and are brought to a temperature which is the resultant of that of the air and of their actual temperature, that is to say, they are brought rapidly to a temperature slightly below  $T_r$ . The advantage of this process 115 resides in the fact that by means of a regulation of the air temperature, the granules reach the temperature  $T_r$  just at the instant when they penetrate into the flame. The dangers of the granules sticking to one another are thus 120 reduced to the absolute minimum, in view of the fact that in practice they only reach a dangerous temperature at the instant of penetrating into the flame.

This process also avoids possibility of the 125 granules agglomerating on the walls of the apparatus, as would be the case if they were placed in suspension in the air during the heating of the latter.

Having been pre-heated, the glass granules 130

penetrate into the flame. The phase "b" is then carried out, during which the granules are instantaneously melted, owing to their having been pre-heated, by being brought to 5 a temperature  $T_b$  higher than  $T_r$ . They take the spherical shape, and then, while travelling towards the upper part of the apparatus, they are rapidly cooled to a temperature  $T/\beta$ , at which they are abruptly solidified, that is to 10 say, phase "c".

It has been established that the velocity at which the granules are injected into the flame should be capable of being adjusted within narrow limits. For example, it is essential 15 that, according to the composition of the glass which is used, this velocity should be varied in order to make allowance for the diameter and the density of the granules.

This adjustment is carried out by acting, 20 for example, on the inlet pressure of the vehicle gas for combustion. In this manner, the granules are projected at a velocity which is the resultant of the air velocity and their own delivery velocity (function of the diameter 25 and density). There is thus obtained the advantage of being able in all cases to adapt the propulsion velocity of the granules, by which it is possible to obtain the maximum output.

30 It is thus possible to fix the exact time during which the glass granules are subjected to the formation process (fusion and solidification) and to limit this time to the absolute minimum.

35 It has been found that the maximum output was obtained when steps were taken to prevent the beads from being left too long at a high temperature. In this manner, the adhesion of the beads to one another is avoided.

40 At the outlet from this shaping zone, the beads travel through the cooling zone which is constituted in such manner as to obtain a sudden solidification (phase "c"), followed by a moderate cooling operation (phase "d").

45 Finally, during the last phase, when the setting up of stresses is no longer to be feared, the cooling is accelerated again (phase "e"). Since the speed of introduction and consequently the initial impulse is a function of

50 the type of beads to be manufactured (diameter and density) and moreover, since the speed of ascent of the gases decreases as they become cooled, the velocity of the beads which are formed decreases and this velocity 55 may fall below the velocity necessary to carry them towards the upper end of the vertical column and towards the separator.

A series of vertical air jets is then arranged in the upper part of the apparatus so as to 60 increase the speed of ascent. There is thus created an eddying effect which is favourable to the last part of the cooling of the beads, that is to say, below the temperature at which hardening can take place.

65 It has been found that a certain proportion

of the beads sometimes avoids being entrained by the hot gases and, on the other hand, it has been seen that it is desirable for the beads to be solidified as rapidly as possible. It is for this reason that a ring of nozzles, through 70 which cold air is blown, is positioned around the burner and at a slightly higher level. The nozzles are vertical or inclined to the vertical, according to requirements. The nozzles are designed to take up the glass granules which 75 could have left the central flame during the initial part of their ascent, and could therefore have dropped out of the effective zone of the said flame. In addition, the nozzles contribute to the formation of a relatively cold gas current immediately after the beads are formed, the current solidifying the beads so that they are not able to adhere to one another, and in addition ensuring the complete entrainment of 80 the products at a uniform velocity and temperature in each horizontal section of the apparatus.

The apparatus, according to Figures 2 and 3, is composed essentially of a vertical column formed by a tubular column 1 of refractory material resting on a support 42 by means of a collar 41. To absorb vibrations fixing means, for example, springs 40 or other equivalent devices, are provided at the base of the column. The tubular column 1 is enclosed 90 by a cooling jacket 2, which latter is traversed by an air current blown by a constant delivery fan 7. Positioned at the base of the column 1 and axially of the latter is a burner 3 which receives fuel gas through a pipe line 4. The 95 line 4 is connected to a supply source via a valve 34, by a flexible tube 22. Air is supplied to the burner 3 through a double pipe system 5, 35 which system opens at 3 around the pipe line 4 and is concentric with the latter. 100

The air delivered by the fan 7 into the jacket 2 leaves the latter through a double pipe system 6, 6A connected to the double pipe system 35, 5 of the burner 3, the pipe line 6A taking the air from the jacket 2 at a plate at which this 110 air has still not been brought to the maximum possible temperature, while the pipe line 6 takes the air which has been pre-heated to the maximum value from the said jacket.

The pipes 6, 6A are fitted with valves 43, 45 115 and communicate with one another through a valve 44.

The fan 7 is operated by a motor 37 of adjustable speed in such manner as to be able to modify the delivery or output of the fan 7 120 according to working conditions.

Opening into the pipe 5 is a pipe 8 positioned at the outlet of a worm 9 controlled by a motor 36 and fed with previously crushed and calibrated glass granules which are introduced into a supply hopper 10. The hopper 10, in conjunction with the worm 9, forms an airtight assembly in order to avoid any leakage of air from the piping system 2, 6 and 5. 125

By means of the three valves 43, 44 and 45, 130

it is possible to obtain several valve setting combinations:—

By closing 44, it is possible to effect the entraining of the glass granules at a moderate temperature, that is to say, clearly below the softening point. The hotter air passing in 6 is then reserved for increasing the temperature of the flame:

By closing 45 and regulating the opening of 10 44 according to requirements, it is possible to use a larger or smaller part of the air which is heated to the maximum and which is coming from 6, for the purpose of conveying the glass granules;

15 By regulating the opening of the three valves, it is possible to achieve various combinations as a function of the temperature to be achieved, the softening temperature of the glass, the delivery of the glass granules and 20 other possible operating conditions.

Provided around the burner 3 is a ring of nozzles 11 which is supplied with air through a pipe system 38 connected to a fan 39. A current of air is sent by this fan into the nozzles 25 11, it being possible for the velocity and temperature of this air to be regulated by suitable conventional means which are widely known. The nozzles 11 are secured to their supports 11A in such manner that their inclination in 30 relation to the axis of the apparatus may be adjusted.

At the upper end of the tubular column 1, an elbow 12 conducts the shaped beads, via a flexible connection 25 towards a separator 13, 35 from which the burnt gases leave by way of the opening 14, while the solid products are deposited in the lower part 15 provided with a box 16 for the collection of the said products.

The apparatus operates as follows:—

40 The glass granules introduced at 10 are carried at a constant speed, determined by the worm 9 controlled by a variable speed motor 36, towards the pipe 8 and fall through the pipe 8 into the air current which latter is circulating in the pipe 5, after having passed through the jacket 2 in which the air is heated to a temperature between 400 and 1000° C., depending upon the requirement.

The hot air entrains the glass granules in 50 the pipe system 5 and gives up its heat to these granules throughout the travel towards the burner 3, in which said air immediately enters into combustion with the gases arriving from the pipe 4. The combustion is rapid and the 55 flame acquires a very high temperature owing to the pre-heating of the air. This pre-heating has been controlled so that the granules are preferably brought to a temperature slightly lower than or immediately before their softening point, which they reach at the instant at 60 which they enter the flame.

While keeping constant the total delivery of air necessary for the combustion, it is possible by means of the valves 43, 44, 45 to regulate late the air supply which entrains the granules

leaving the pipe 8, and consequently to regulate separately the temperature of the flame and the velocity of the granules when they pass into the burner 3.

At this instant, the glass granules are projected upwardly by the air jet by which they are entrained, owing to this impulse, the glass granules are not able to fall on to the sides of the burner 3 and thereby avoid the action of the latter. The granules will thus reach a zone in the apparatus at which, owing to the air injected through the nozzles 11, a uniform gas current exists throughout the cross-section of the apparatus, as has already been explained above.

In this manner, provided that the granules are projected with a velocity sufficient for reaching this height, they will be taken up in the homogenised vapour current and it will be ensured that all the granules will be carried upwardly, thereby preventing a proportion of them from dropping down to the lower part of the column 1.

It has been found that it is desirable to be able to regulate the inclination of each of the 90 nozzles 11 individually.

This operation is carried out by known means, for example, by separately mounting each nozzle 11 on a ball joint 11B.

By this means, it is possible to neutralise 95 over the entire periphery the effect of expansion of the burner flame and of being able to obtain a current of hot gases which are as uniform as possible over the entire section of the tube 1.

The burner 3 is regulated so as to obtain a short and hot flame, whereby the beads are cooled almost as soon as they are formed owing to the injection of air through the nozzles 11, and are, in consequence solidified in the form 105 of spheres.

Owing to the possibility of regulating the velocity and temperature of the air issuing from the nozzles 11, it is possible to fix very accurately the optimum conditions for carrying out the process of fusion and solidification (phases b and c).

The beads then pass through the zone of influence of the cooling jacket 2. In the upper part of the latter, the cooling is relatively 115 moderate owing to the circulation of air blown in by the fan 7, this cooling being the zone "d" of the diagram.

In the upper part of the column 1, the beads having reached a temperature at which it is no longer possible for tensions to be set up, are subjected to a more intensive cooling.

For this purpose, there is provided a fresh series of nozzles 18 fed through a casing 19 connected by a duct 20 to a fan 33. Jets of 125 cold air which are directed tangentially in relation to the column 1 are blown through the nozzles 18 into the interior of the column 1 in order to create a turbulent motion. The beads are thus cooled because of the jets of 130

cold air and the turbulent motion. This is phase "e" of the diagram, and on the conclusion of which phase "e" the beads are brought to a temperature in the region of 5 150—200° C.

During the phases "d" and "e", those beads which have not been cooled, and which come into contact with those parts of the walls of the column 1 cooled by the circulation of 10 air in 2 and by the jets of air leaving the nozzles 18, would be able to adhere to the walls. The accumulation of said beads may cause a decrease in the cross-section of the apparatus.

15 In order to avoid this accumulation of beads on the walls, the apparatus is subjected to vibrations which destroy or detach the agglomerated products as they are formed. These vibrations are generated by a vibrator 17 fixed 20 to the wall of the tube 1 and operated constantly or at more or less close intervals, according to requirements.

It is for the purpose of permitting the column 1 to vibrate that the latter is mounted 25 on its support 42 by means of the springs 40 or other devices absorbing the vibrations, which are interposed between the said support and the collar 41.

The beads leaving the effective zone of the 30 jacket 2 are directed by an elbow 12 towards a separator 13.

In certain cases for example, when handling less fusible glass, it has been found that it may be desirable to increase the radius of the 35 flame. According to the invention, this is achieved by increasing its power of emission, for example, by adding products, such as heavy hydrocarbons to the liquid fuel, the said products rendering the fuel illuminating.

40 It is also possible to improve the flame radius by increasing the turbulence of the flame at the immediate outlet of the burner, this increase being obtained by supplying the gas or air by a pulsating device, a piston compressor or other apparatus. Such a device has 45 the additional advantage of being better able to hold the glass granules in suspension, this being important if the glass is dense and also if the spheres to be manufactured are relatively large.

As the pre-heating temperature of the granules is very close to, or immediately precedes, their softening temperature, experience has shown that a slight derangement of the 55 control apparatus may give a temperature which is just too high, with which there is danger of the granules adhering to one another. In order to obviate this disadvantage, the invention provides the possibility of causing 60 the air charged with glass granules to vibrate, this giving greater mobility to the said granules and reducing the danger of adhesion.

This result is obtained by connecting a 65 vibrator 24 to the last section of the pipe 5. The vibrator 24 is formed, for example, by a

known device such as a diaphragm 24A actuated by an electromagnetic vibrator 46 so as to set up acoustic vibrations which are transmitted to the air and in turn cause the latter to vibrate.

The vibrations set up either by 17 or by 24 are prevented from extending to the complete installation by inserting flexible connections 22, 23, 23A and 25 in front of and following that part of the apparatus in which the beads 75 are formed.

The separator 13 may take different forms, depending on the manufacturing conditions, for example, according to whether products of greater or lesser degrees of fineness are 80 treated or whether the supply of the glass granules is high or low.

The simplest form will be that of a dust-separating cyclone, at the entrance to which the burnt gases are subjected to a velocity 85 decrease which enables the beads to be deposited, and consequently fall into the lower part 15 constituting a box provided with a shut-off device 16 (a cap or the like) through which the beads are periodically discharged. The exhaust 90 gases from which the beads are removed escape upwardly and are discharged through the opening 14 at the top of the separator 13. The operation is carried out in such manner that the temperature of the exhaust gases on 95 their discharge from the separator is slightly higher than 100°. In this way, it is possible to avoid the water vapour contained in the exhaust gases from being deposited on the beads whereby the latter are discharged in a 100 dry state.

Under certain conditions the ordinary cyclone does not give an output of 100% and some of the smallest beads are entrained by the exhaust gases.

In order to obviate this disadvantage, there will be employed a separator of the type shown in Figure 4, namely:—

The beads, after having been formed, pass into the flexible connection 25 and through an 110 elbow 26, one branch of which opens vertically into a cyclone 47. When they leave this vertical branch, the hot gases charged with beads impinge against a baffle plate 27 which stops the beads and causes them to rebound 115 along paths directed downwardly, which causes the beads to fall towards the bottom of the apparatus where they are collected.

It has been found that the separation is improved if the exhaust gases leaving the vertical part of the elbow 26 are given a spinning motion. For this purpose, a screw 31 for producing a whirling motion is disposed in the outlet of the vertical branch of the elbow 26, which motion, because of centrifugal force, 125 combined with the effect of the baffle plate 27, tends to displace the beads from the axis of the apparatus in proportion to their weight. There is thus obtained a grading of the beads by dimensions, since their weight is propor- 130

tional to the diameter. Advantage is taken of this fact by providing an annular separating partition 28, the products falling inside and outside the said partition and thus being separately collected: the largest beads collect in the box 30 and the smallest beads in the box 29.

The present invention lends itself to numerous constructional modifications without thereby departing from the actual scope of the invention. For example, the limits of the pre-heating and of the possibilities of regulating the pre-heating of the glass granules before they are injected into the flame may be amplified by providing the apparatus as described above in connection with Figure 2 with an independent pre-heating means comprising for example, a tube *a* connected at one end to the lower part of the jacket 2 or directly to the fan 7 and, at the other end, by means of regulating valves *c* and *d*, to the pipes 6A and 6, respectively, the tube *a* being combined with a gas jet *b* connected to a supply pipe by a flexible connection 22A. By using this independent pre-heating means *a*, *b*, *c* and *d*, it is possible to intensify in an adjustable manner both the pre-heating of the air in the pipe 6A intended for pre-heating the glass granules, and also the pre-heating of the air introduced into the part 35 of the burner in order to leave the latter by the external concentric pipe, and suitably to regulate these two pre-heating intensifier systems in relation to one another.

What we claim is:—

1. Process for manufacturing beads (solid glass spherules) by the thermal treatment of glass granules obtained by crushing glass chips, in which process a pre-heated mixture of the said granules, a fluid supporting combustion and/or a combustible fluid serving as vehicle media is injected into a flame fed by the fluids, and in which said granules are transformed by fusion and surface tension into beads which beads are then cooled and separated from the vehicle fluids, wherein the pre-heating of the glass granules is continued up to a temperature slightly or immediately below the softening temperature of the glass and is carried out at a high speed as a result of the granules being dispersed in at least one of the said fluids, which latter is previously pre-heated to a temperature a little higher than the said softening temperature.

2. Process according to claim 1, wherein the beads, as soon as they are formed by the rapid fusion of the granules which are pre-heated and injected into the flame, are first of all solidified at an abrupt speed, keeping to an absolute minimum the time during which the beads are liable to adhere to one another, and then, after they are solidified the said beads are cooled at a much slower speed, thereby limiting the hardening and the internal tensions which result therefrom.

3. Process according to claim 1 or 2, wherein the glass granules are pre-heated rapidly, first

of all up to a temperature slightly or immediately below their softening temperature and then up to the softening temperature by their introduction into and their entrainment by, the fluid or fluids feeding the flame which latter is preferably directed upwardly and wherein the granules are then injected in this pre-heated condition with the said fluid or fluids into the said flame and are brought by the latter rapidly to a temperature higher than their softening temperature.

4. Process according to any one of claims 1 to 3, wherein the beads which have been formed are subjected to a cooling process, which comprises at least three stages, the first stage being abrupt and terminating at the upper point of structural transformation, the second stage being moderate and terminating at the lower point of structural transformation and the third stage being abrupt and terminating at a temperature slightly higher than 100° C. and wherein after said cooling process the beads are separated from the vehicle fluids and are collected in a graded condition, by a centrifugal action, according to their order of size.

5. Process according to any one of the preceding claims, wherein the emissive power of the flame is regulated by adding to the combustible fluid, a proportion of products which render the flame illuminating such as heavy hydrocarbons.

6. Process according to any one of the preceding claims, wherein the flame is caused to be turbulent by intermittently supplying said flame with a combustible fluid and/or a supporter of combustion.

7. Process according to any one of the preceding claims, wherein the fluid or fluids serving as vehicle media for the glass granules are subjected to vibrations.

8. Process according to any one of the preceding claims, wherein the flame is formed within an orientatable ascending air current, the velocity and temperature of which air current are adjustable.

9. Process according to any one of the preceding claims, wherein the vehicle fluid current charged with the formed beads is caused to pass through a zone of increasing cooling intensity.

10. Process according to any one of the preceding claims, wherein the separation of the beads from the vehicle fluids is assisted by imposing a spinning motion on the said fluids, after the first cooling phase of the beads.

11. Apparatus for carrying out the process according to any one of the preceding claims, comprising a substantially vertical tubular column, the lower end of which has opening thereto an upwardly directed burner which is supplied with fuel, a supporter of combustion and glass granules, and a separator which adjoins the upper end of the said column, wherein at least one of the pipes feeding the burner with a fluid for supporting combustion

- and/or a combustible fluid is combined with at least one device for pre-heating and regulating the temperature, and wherein the device supplying glass granules opens into at least one 5 of said pipes.
12. Apparatus according to claim 11, wherein the burner comprises a central fuel pipe surrounded by two concentric pipes for the combustion fluids, there being a jacket surrounding 10 part of said column, the jacket serving to preheat the preferably controlled, circulating air which is supplied by an adjustable constant delivery fan, and wherein each of said concentric pipes is coupled by a connecting pipe to 15 said jacket, the couplings being at points where the temperatures are different, there being a regulating valve provided in each of said connecting pipes and a common regulating valve which permits inter-communication between 20 said connecting pipes, and wherein the supply device for the glass granules opens into that one of said connecting pipes which is disposed between the central fuel pipe and the other of 25 said concentric pipes.
13. Apparatus according to claim 11 or 12, and further comprising an air supply device, which may be heated independently and which is connected to an adjustable constant delivery fan and also by means of one or more regulating valves, to the pipe or pipes feeding the 30 burner with pre-heated fluid.
14. Apparatus according to claims 11 to 13, wherein the pre-heating jacket is connected to the concentric pipes by separate regulatable 35 pipes ending at points of different temperature, of the said jacket and wherein the regulatable pipes are connected to one another by adjustable connecting means.
15. Apparatus according to any one of 40 claims 11 to 14, wherein a ring of preferably orientatable and upwardly directed nozzles extends around the burner in the lower part of the tubular column, the said nozzles being combined with means for supplying air in an adjustable quantity and at a variable temperature.
16. Apparatus according to any one of claims 45 11 to 15, wherein a ring of nozzles which may be orientatable, opens into the tubular column downstream of the cooling zones or zones of 50 the said column.
17. Apparatus according to any one of claims 11 to 16, wherein the burner is connected to a device for pulsating the supply of combustible fluid and/or a fluid supporting combustion. 55
18. Apparatus according to any one of claims 11 to 17, wherein the pipe or pipes into which the device feeding the glass granules is adapted to open, communicates with a vibrator.
19. Apparatus according to any one of claims 60 11 to 18, wherein the tubular column is combined with a vibrating means and rests on an elastic supporting means capable of absorbing the vibrations.
20. Apparatus according to any one of claims 65 11 to 19, wherein the upper part of the tubular column opens into a separator, the latter being formed by a chamber provided with an upwardly sloping deflector facing the mouth of a pipe connecting the upper part of the said 70 tubular column to said separator, the mouth being surrounded by at least two concentric outlets and being equipped internally with a helical wall for imparting a spinning motion to the gas current charged with beads which current is directed against the said deflector.
21. Apparatus according to any one of claims 17 to 20, wherein the parts thereof subjected to separate vibrations are connected to one another and to the fixed parts by flexible 80 couplings.
22. Process for manufacturing beads, substantially as hereinbefore described with reference to the accompanying drawing.
23. Beads when produced by the process as 85 claimed in any one of claims 1 to 10 and claim 22.
24. Apparatus for manufacturing beads, substantially as hereinbefore described with reference to the accompanying drawing. 90
25. Beads when produced by the apparatus claimed in any one of claims 11 to 21 and claim 24.

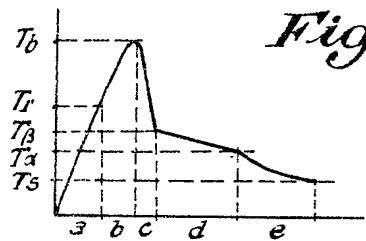
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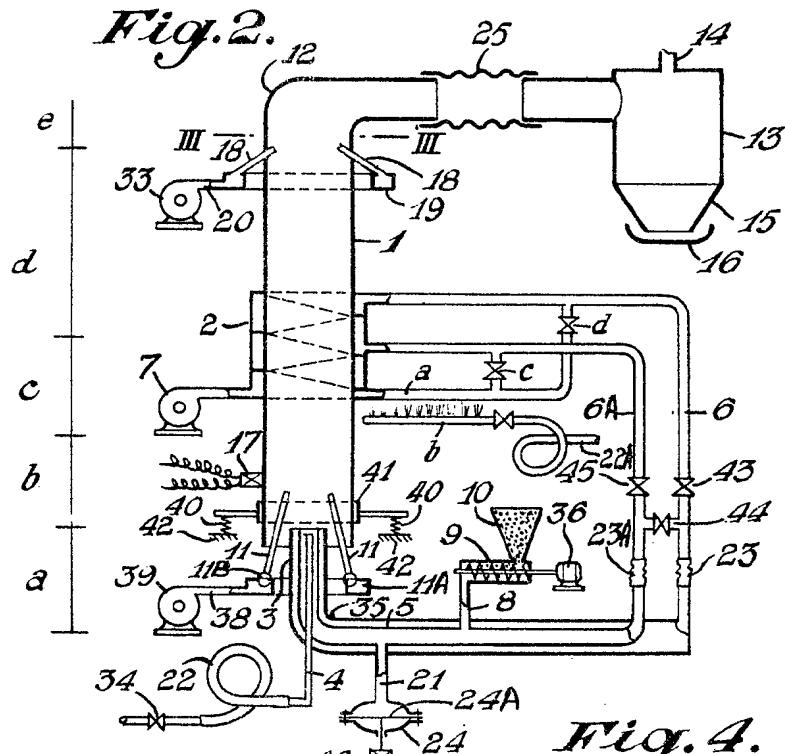
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## **COMPLETE SPECIFICATION**

This drawing is a reproduction of  
the Original on a reduced scale.



*Fig. 1.*



*Fig. 3.*

